JOINT STRIKE FIGHTER
AUTONOMIC LOGISTICS
PROGNOSTICS & HEALTH MANAGEMENT

Al Bodnar
Joint Strike Fighter Program Office
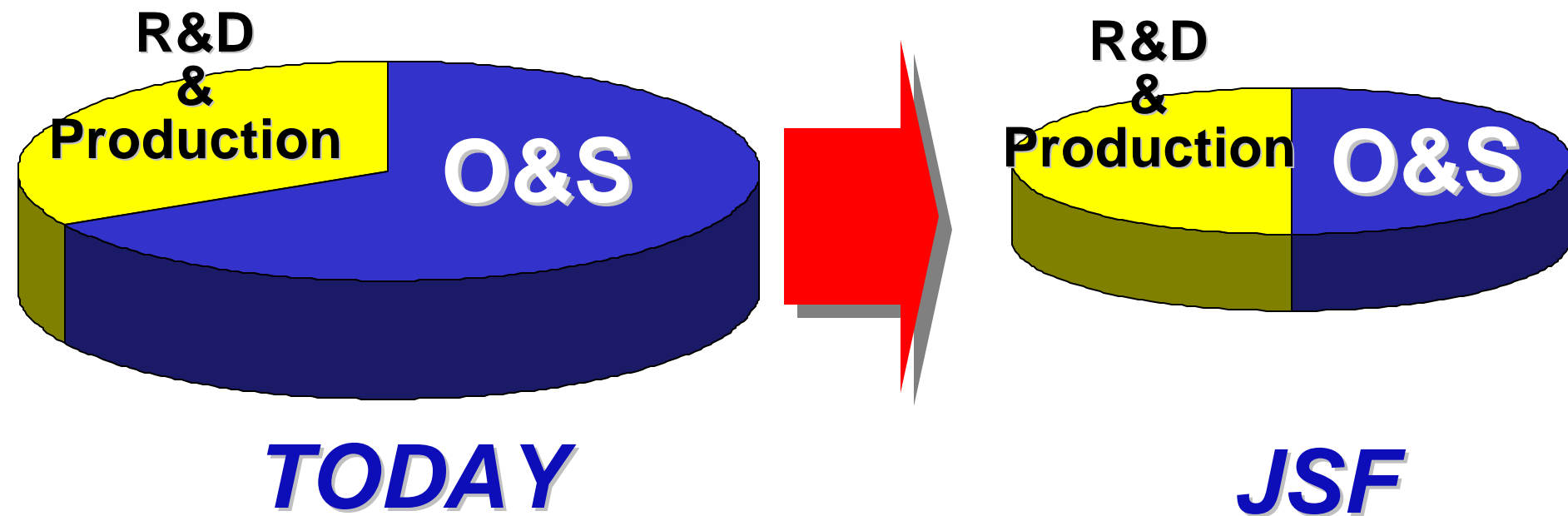
VISION

BE THE MODEL ACQUISITION PROGRAM FOR JOINT SERVICE AND INTERNATIONAL COOPERATION

DEVELOP AND PRODUCE AN AFFORDABLE NEXT GENERATION STRIKE FIGHTER WEAPON SYSTEM AND SUSTAIN IT WORLDWIDE

AFFORDABILITY CHALLENGE

R&D
&
Production

O&S

TODAY

R&D
&
Production

O&S

JSF
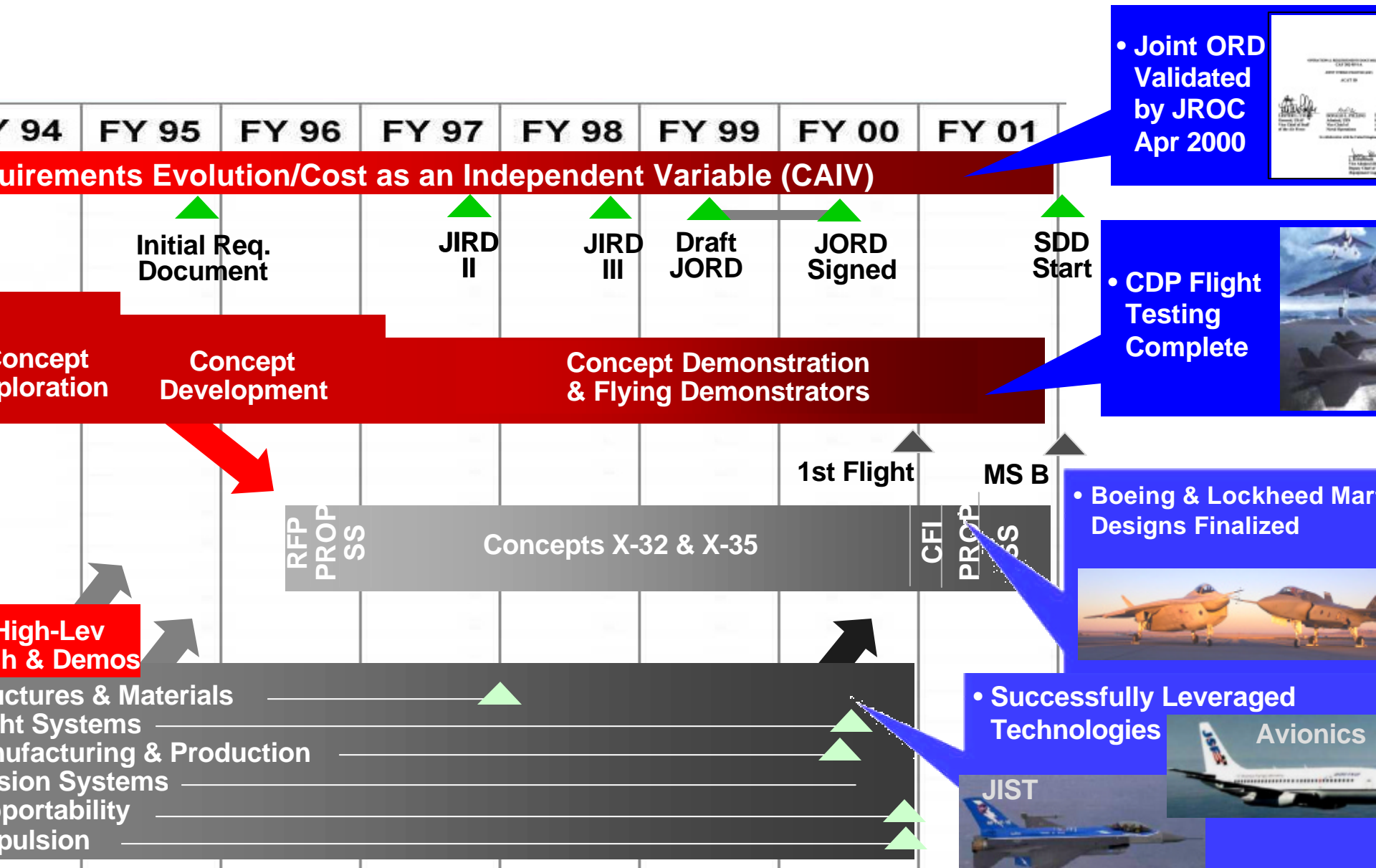
Note: O&S (Operations & Support) = Whole Life Support

OVERVIEW

- **JSF Background**

- **AutoLog Approach**

- **Summary**

CONCEPT DEMONSTRATION PHASE
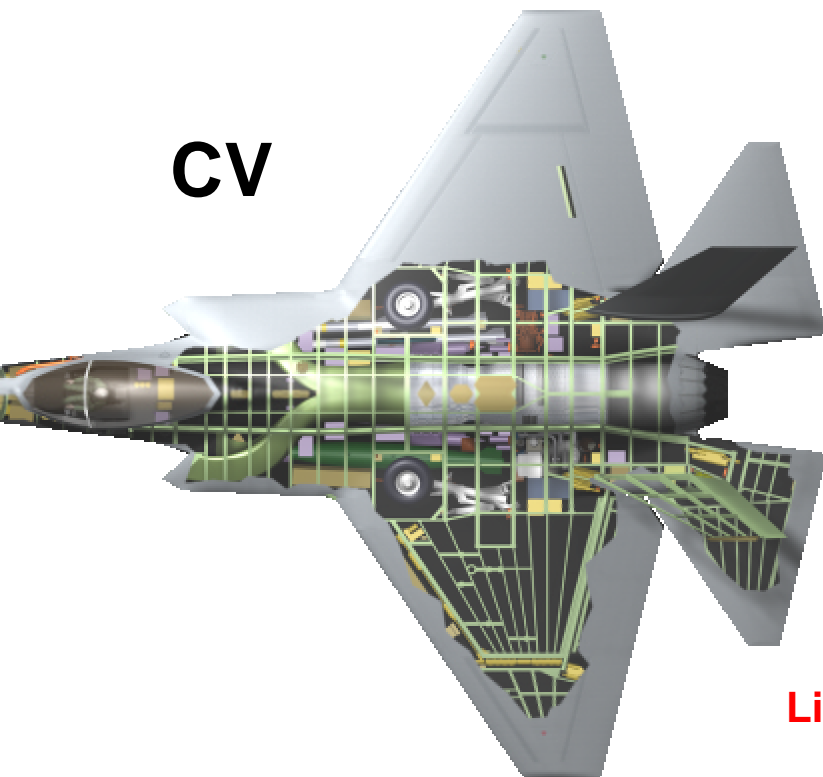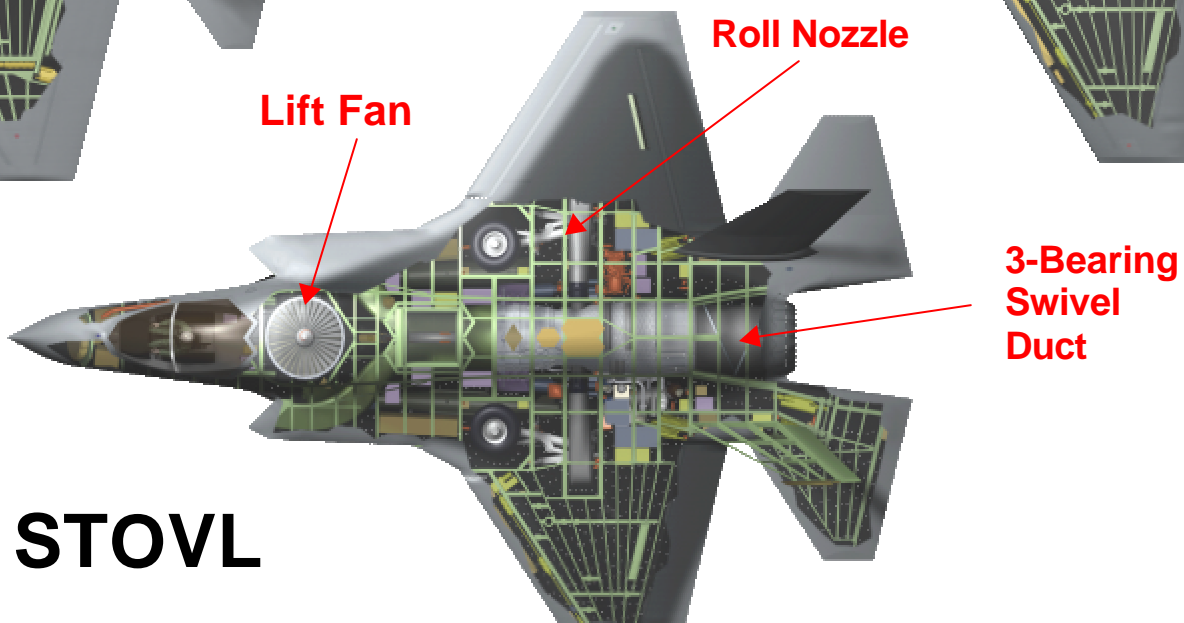
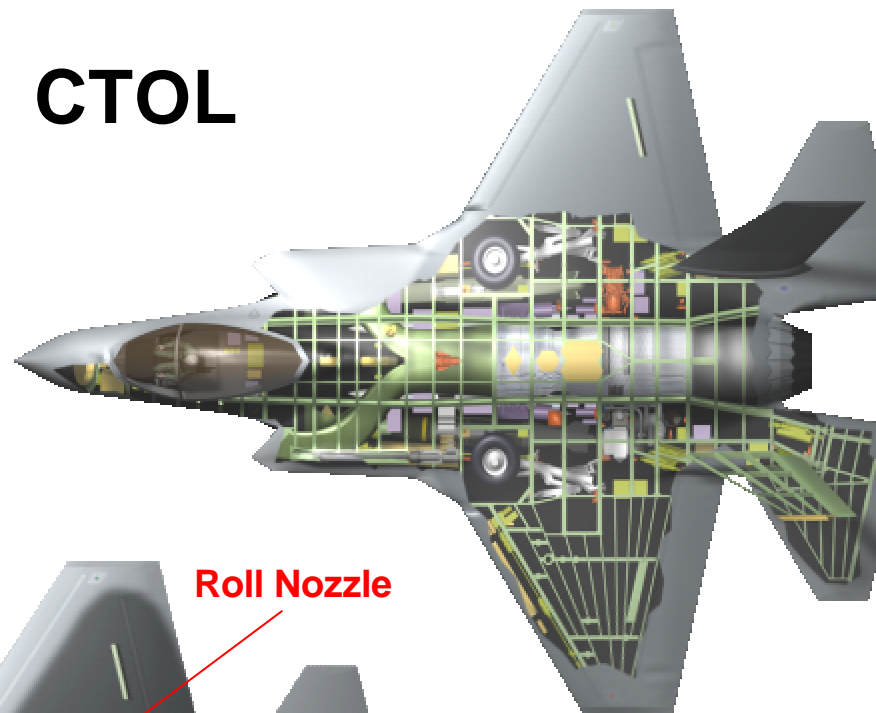| FY 94	FY 95	FY 96	FY 97	FY 98	FY 99	FY 00	FY 01

quirements Evolution/Cost as an Independent Variable (CAIV)

Initial Req. Document

JIRD II

JIRD III

Draft JORD

JORD Signed

SDD Start

- **Joint ORD Validated by JROC Apr 2000**

- **CDP Flight Testing Complete**

oncept ploration

Concept Development

Concept Demonstration & Flying Demonstrators

1st Flight

MS B

RFP PROP SS

Concepts X-32 & X-35

CFI PROP SS

- **Boeing & Lockheed Mar Designs Finalized**

High-Lev h & Demos

ctures & Materials
ht Systems
nufacturing & Production
sion Systems
portability
pulsion

- **Successfully Leveraged Technologies**

Avionics

JIST

LOCKHEED MARTIN
MULTI-SERVICE DESIGN

CV

CTOL

STOVL

Roll Nozzle

Lift Fan

3-Bearing Swivel Duct

JSF ENGINE INTERCHANGEABILITY

Lockheed Martin Concept

CV/CTOL

JSF F135 or
JSF F136

STOVL
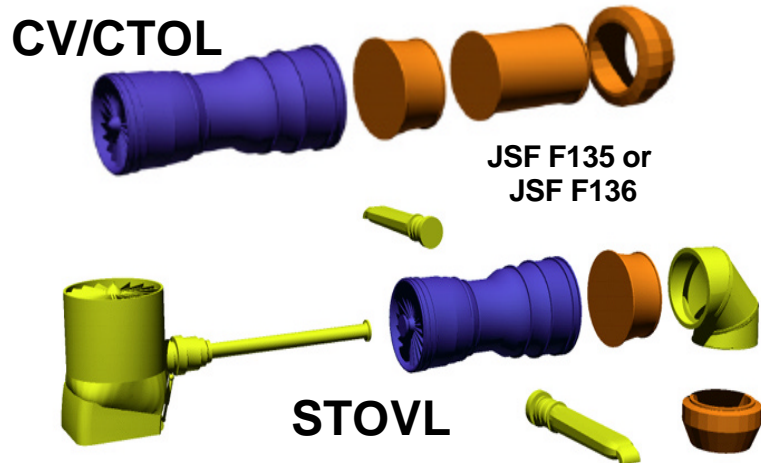
COOPETITION

- **P&W F135 & GEAE/RR F136 Engines Will Be Physically & Functionally Interchangeable**
- **All JSF Aircraft Will Be Able to Use Any JSF Engine**
- **Common JSF Autonomic Logistics System Interfaces**

STATUS OF INTERNATIONAL COOPERATIVE AGREEMENTS

- **Cooperative Partners**

  Level I - UK Memorandum of Understanding (MOU)
  Signed 17 January 2001

  Level II – Italy MOU Signed 24 June 2002

  Netherlands MOU Signed 10 June 2002

  Level III - Turkey MOU Signed 11 July 2002

  Canada MOU Signed 7 February 2002

  Denmark MOU Signed 28 May 2002

  Norway MOU Signed 20 June 2002

- **Anticipated Signings**
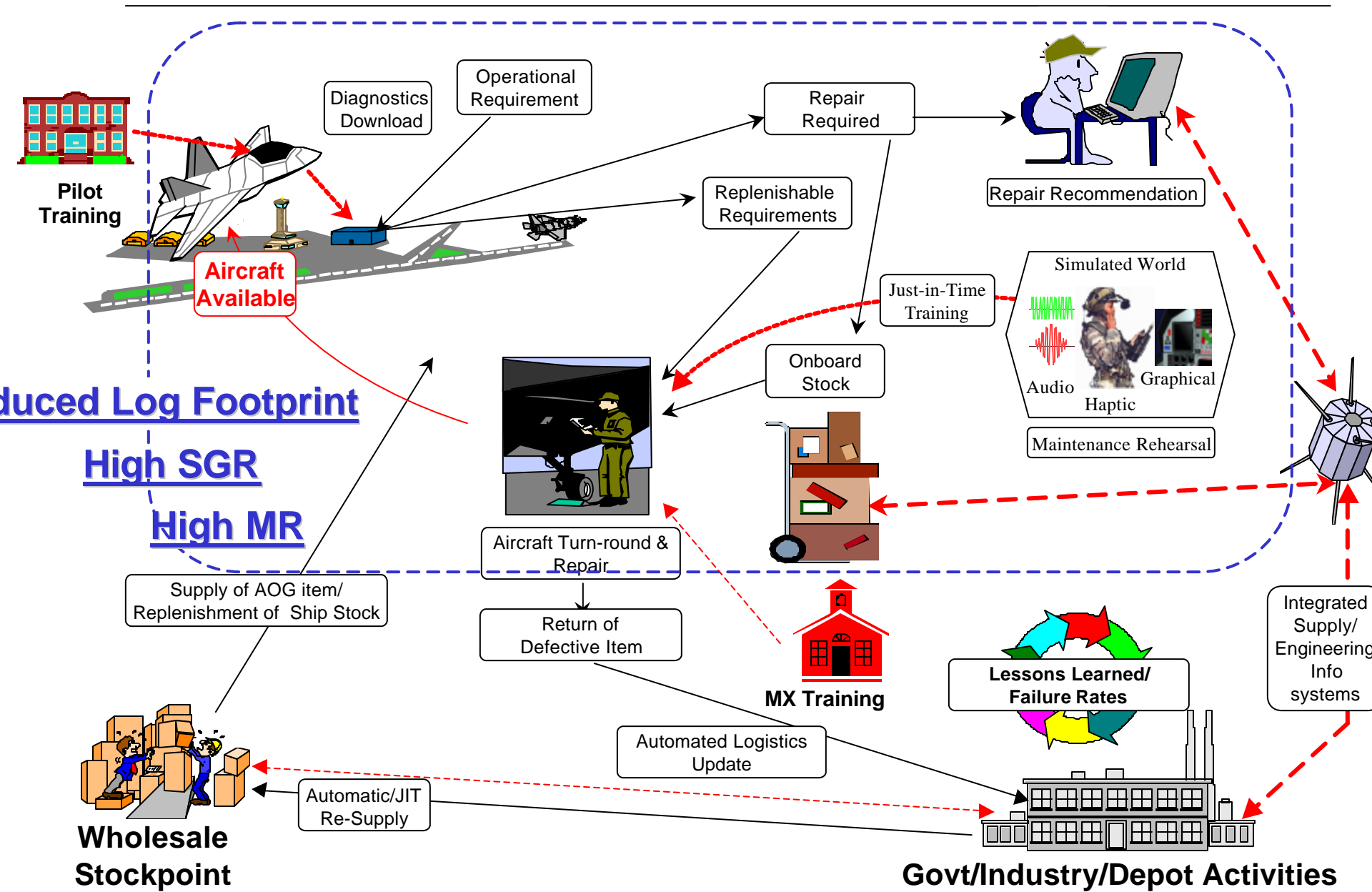
  Australia (Estimate 31 October 2002)

AUTONOMIC LOGISTICS VISION

A comprehensive logistics support environment for the JSF which has these key features:

- **A highly reliable aircraft which encompasses Prognostics & Health Management**

- **A technologically enabled warfighter**

- **A Joint Distributed Information System**

- **A logistics infrastructure that is sufficiently responsive to support requirements**
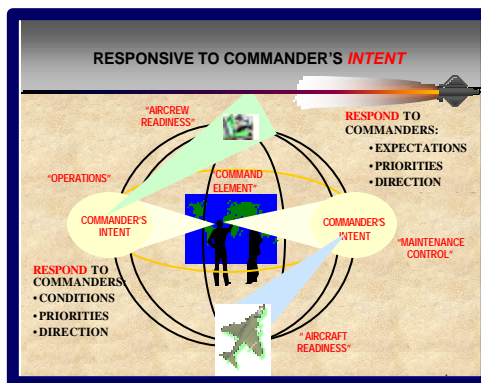
AUTONOMIC LOGISTICS CONOPS

Pilot Training

Diagnostics Download
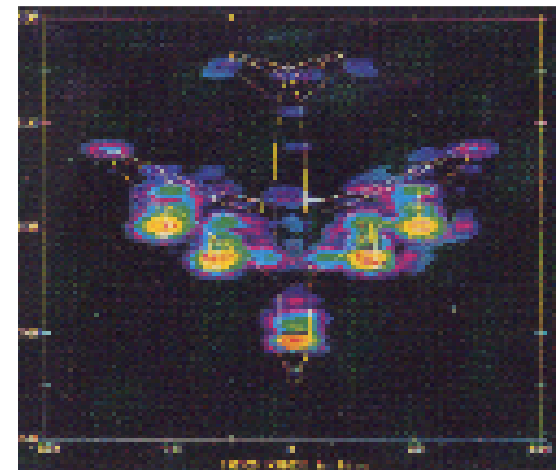
Operational Requirement

Repair Required

Repair Recommendation

Replenishable Requirements

Aircraft Available

Simulated World

Just-in-Time Training

Audio   Graphical

Haptic

Maintenance Rehearsal

Onboard Stock

duced Log Footprint

High SGR

High MR

Aircraft Turn-round & Repair

MX Training

Lessons Learned/ Failure Rates

Integrated Supply/ Engineering Info systems

Supply of AOG item/ Replenishment of Ship Stock

Return of Defective Item

Automated Logistics Update

Wholesale Stockpoint

Automatic/JIT Re-Supply

Govt/Industry/Depot Activities

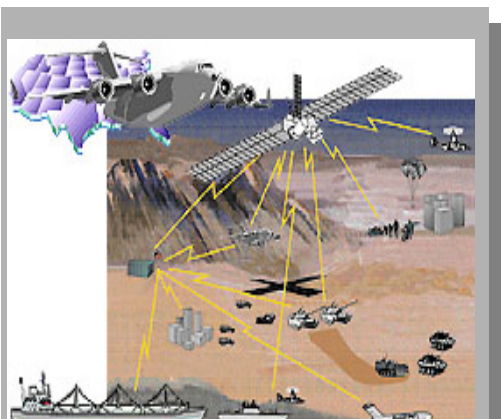# AUTONOMIC LOGISTICS TECHNOLOGIE

JSF Paintless Aircraft

CACE

RESPONSIVE TO COMMANDER'S *INTENT*

"AIRCREW READINESS"

RESPOND TO COMMANDERS:
• EXPECTATIONS
• PRIORITIES
• DIRECTION

"OPERATIONS"

"COMMAND ELEMENT"

COMMANDER'S INTENT

COMMANDER'S INTENT

"MAINTENANCE CONTROL"

RESPOND TO COMMANDERS
• CONDITIONS
• PRIORITIES
• DIRECTION

" AIRCRAFT READINESS"

Supportable LO

Prognostics & Health Management (PHM)

Oil Condition Monitor (OCM)

Joint Distributed information system (JDIS)
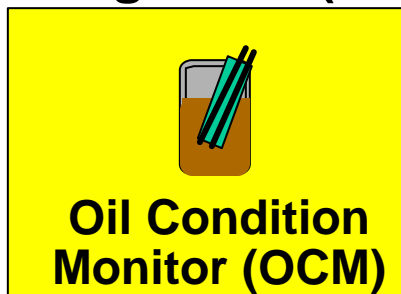
Reliability & Maintainability
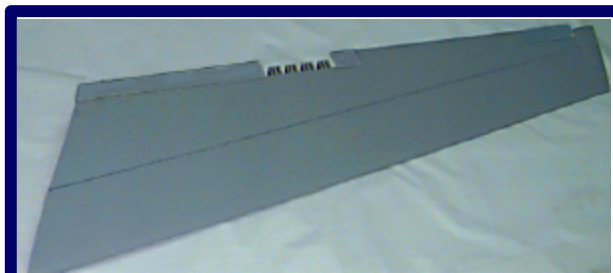
Training

PROGNOSTICS AND HEALTH MANAGEMENT

- **Why Did We Choose This Technology?**

  - **Enable Autonomic Logistics**

  - **Enhance Flight Safety**

    - **Single Engine Aircraft, Must Have Dual Engine Reliability**

  - **Increase Sortie Generation Rate**

  - **Eliminate False Alarms**

  - **Eliminate CND's and RTOK's**

  - **Reduce Life Cycle Costs**

  - **Maximize PHM Benefit from Limited Specialized Sensors**

  - **Take Max Advantage of the "Smart" Digital Aircraft**

Natural Evolution of Legacy Diagnostic Capabilities Coupled with the Added Functions, Capabilities, and Benefits offered by New Technologies

What is it?

- **Diagnostics** – is the process of determining the state of a component to perform its function(s)

- **Prognostics** – is predictive diagnostics which includes determining the remaining life or time span of proper operation of a component

- **Health Management** – is the capability to make appropriate decisions about maintenance actions based on diagnostics/prognostics information, available resources and operational demand.
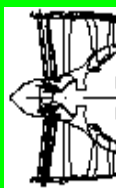
Boarded

Under development

Not boarded

Eddy Current Blade Sensor (ECS)
GDATS

Ingested Debris Monitoring System (IDMS)

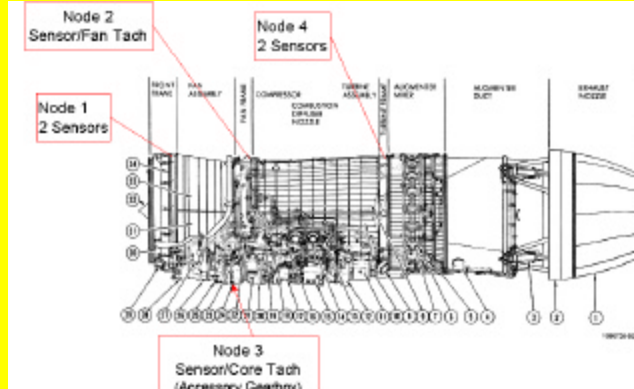**Engine Distress Monitoring System (EDMS)**
Stewart Hughes Ltd

Piezoceramic Patch Crack Detection (PZT)
UTRC
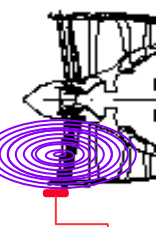
Acoustic FOD Detector (AFD)
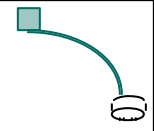
Beacon-Based Exception Analysis for Maintenance (BEAM) JPL

Robust LASER Inferometer (RLI)
Epoch Engineering

Node 2
Sensor/Fan Tach

Node 4
2 Sensors

Node 1
2 Sensors

Node 3
Sensor/Core Tach
(Accessory Gearbox)

MEMS Sensors
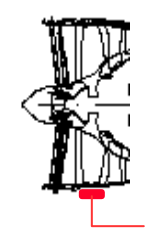
Blade Vibration meter (BVM8X)
ood Technology

Oil Flow
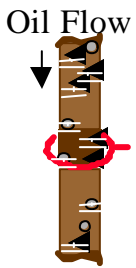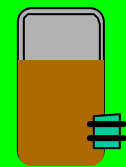
Electrostatic Bearing Monitor (EBM)
ExperTech

Oil Flow

Electrostatic Oil Debris Monitor (EODM)

Oil Condition Monitor (OCM)
UDRI

Communications

Diagnostic Processor

General Purpose Processing

Signal Processing

Signal

Power Interface/Generation

Sensing

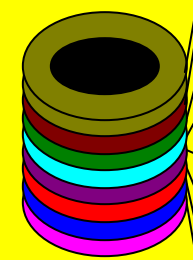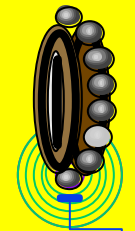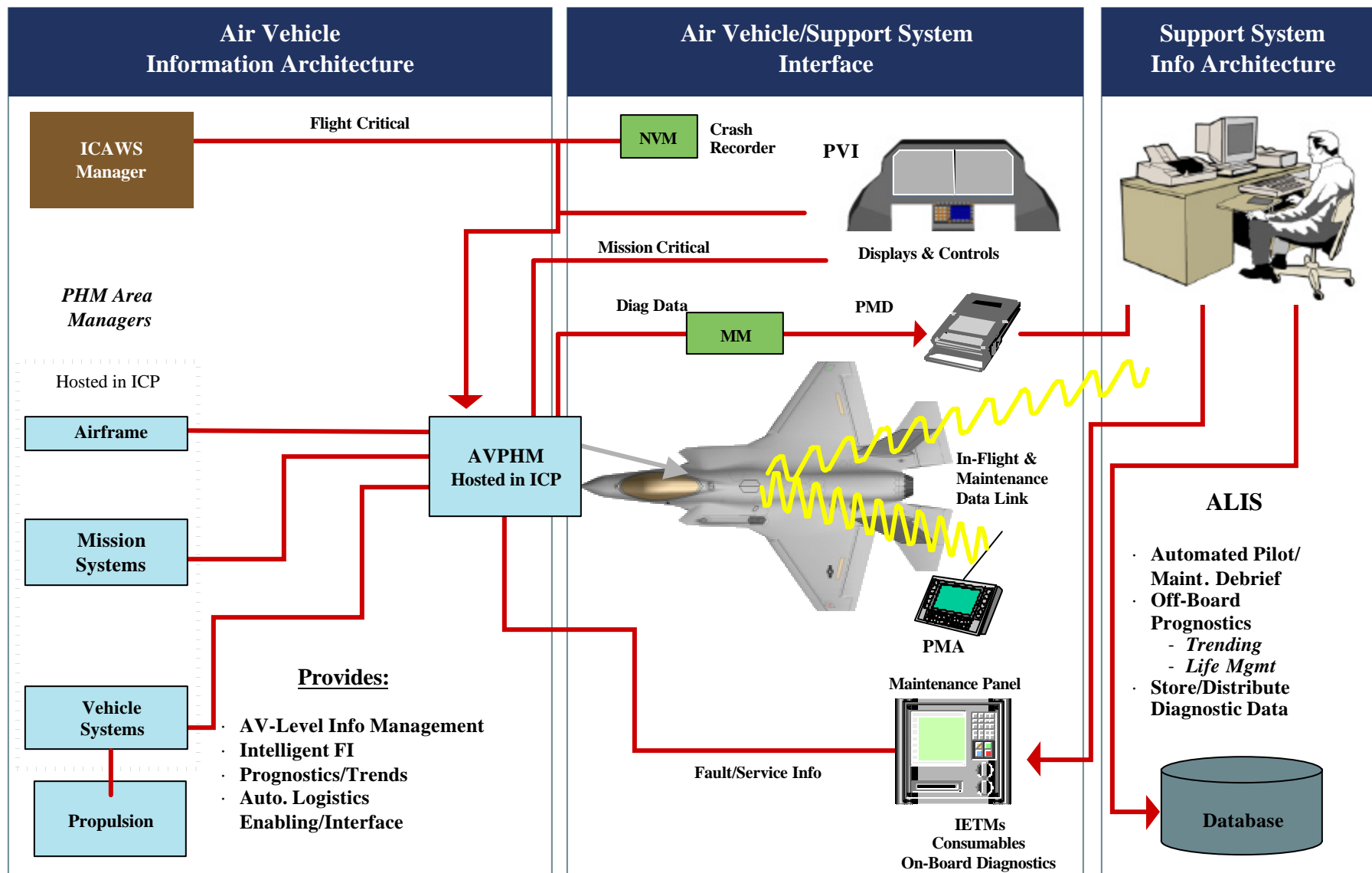Self calibration/Active Cancellation

Stress Wave Analysis (SWAN)
DME

9 Oil Debris itor (ODM)
GasTOPS

PHM ARCHITECTURE

A Comprehensive Approach to Prognostics & Health Management

Air Vehicle Information Architecture

ICAWS Manager — Flight Critical

PHM Area Managers

Hosted in ICP
- Airframe
- Mission Systems
- Vehicle Systems
- Propulsion

AVPHM Hosted in ICP

Provides:
- AV-Level Info Management
- Intelligent FI
- Prognostics/Trends
- Auto. Logistics Enabling/Interface

Air Vehicle/Support System Interface

NVM — Crash Recorder

PVI — Displays & Controls

Mission Critical

Diag Data — MM — PMD

In-Flight & Maintenance Data Link

PMA

Maintenance Panel

Fault/Service Info

IETMs Consumables On-Board Diagnostics

Support System Info Architecture

ALIS
- Automated Pilot/ Maint. Debrief
- Off-Board Prognostics
  - *Trending*
  - *Life Mgmt*
- Store/Distribute Diagnostic Data

Database

- **Reflected in ORD and JMS Requirements**
- **Reaches across the entire airframe**
  - **Mission Systems**
    - **FD/FI – In flight reconfiguration**
  - **Structures**
    - **Intelligent Load Monitoring**
  - **Propulsion**
    - **Dual engine safety with single engine**
  - **VMS**
    - **Electronics Prognostics**
  - **Subsystems**
    - **Hydraulics**
    - **Fuel System**
    - **Electric Power System**
    - **APU**
    - **Drive Shafts**
    - **Etc…**

SUMMARY

- **PHM is Critical to JSF Autonomic Logistics**

- **Many Challenges Ahead**

- **JSF has the Opportunity to Change the Way Weapon Systems are Supported**

**Joint Strike Fighter
Autonomic
Logistics System**